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MARKET DISEASES OF FRUITS AND VEGETABLES

Beets, Endive, Escarole, Globe Artichokes, Lettuce, Rhubarb, Spinach, Swiss Chard, and Sweetpotatoes

BY

GLEN B. RAMSEY
Senior Pathologist
and
JAMES S. WIANT
Associate Pathologist

Division of Fruit and Vegetable Crops and Diseases
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration

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By GLEN B. RAMSEY, *senior pathologist*, and JAMES S. WIANT, *associate pathologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

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[1] This publication is the ninth in a series designed to aid in the recognition and identification of pathological conditions of economic importance affecting fruits and vegetables in the channels of marketing, to facilitate the market inspection of these food products, and to prevent losses from such conditions. It represents an extended revision and elaboration, with the addition of colored illustrations, of a preliminary publication entitled "Handbook of Diseases of Vegetables Occurring Under Market, Storage, and Transit Conditions," prepared by George K. K. Link and Max W. Gardner, and published by the Department of Agriculture in 1919 especially for the use of the food-products inspectors of the Bureau of Agricultural Economics and never distributed to the public. The original colorings for plates 3; 5, *A*; 8; and 9 are by Glen B. Ramsey. The colored photographs for plates 4; 5, *B, C, D*; 6; and 12 were prepared in collaboration with Webster Bros., Chicago, Ill. The photographs for plates 14; 15, *C*; and 18 were furnished by L. L. Harter, of the Division of Fruit and Vegetable Crops and Diseases, and that for plate 10, *C*, by H. H. Zimmerley, of the Virginia Truck Experiment Station.

The previous Miscellaneous Publications of this series are No. 98 (potatoes), No. 121 (tomatoes, peppers, and eggplants), No. 168 (apples, pears, and quinces), No. 228 (peaches, plums, cherries, and other stone fruits), No. 292 (crucifers and cucurbits), No. 340 (grapes and other small fruits), No. 440 (asparagus, onions, beans, peas, carrots, celery, and related vegetables), and No. 498 (citrus and other subtropical fruits).

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BEETS

The beet (*Beta vulgaris* L.) is grown primarily for its fleshy roots, although the young, succulent tops are also often used as greens. The choicest of the garden varieties have a rich red color and moderate-sized, smooth roots that are sweet and of fine texture. The field, or sugar, beets are yellow to white and are grown for the production of sugar.

Early garden beets are usually marketed in the fresh, crisp condition and should be free from disease. The tops are especially susceptible to decay by the bacterial soft rot organisms (p. 2), and occasionally by the gray mold fungus, during transit and marketing. Cercospora leaf spot sometimes disfigures the tops of garden beets, and it causes severe damage to the sugar-beet crop. Any leaf disease which reduces the normal leaf area of the plant, such as curly top (virus) or rust (*Uromyces betae* (Pers.) Lév.), is likely to cause dwarfing and poor development of the roots. The growing roots are subject to black rot, crown gall (*Agrobacterium tumefaciens* (E. F. Sm. and Town.) Conn), fusarium rot (*Fusarium* spp.), and rhizoctonia root rot (*Corticium solani* (Prill. and Del.) Bourd. and Galz.).

The late beet crop is topped and either marketed immediately or stored for winter use like potatoes. Beet roots without mechanical wounds and free from disease will remain firm and crisp for several months if stored in a cool place. The mature roots are not subject to many diseases. Occasionally they are affected by black rot, blue mold rot (*Penicillium* sp.), fusarium rot (*Fusarium* spp.), internal black spot, and scab.

(See *8*, *91*.)[2]

Bacterial Soft Rot

(*Erwinia carotovora* (Jones) Holland and other organisms)

Bacterial soft rot is not as common on the roots of beets as it is on other root crops, such as carrots and turnips. However, it is the chief cause of loss of leaves and stems of beets when they are shipped and marketed as young bunch beets.

Breaks in the protective skin of plant tissues, moderate temperatures, and an ample supply of moisture are predisposing factors for this rot. Young beets are easily bruised in harvesting, and the leafstalks also are often wounded when the beets are tied into bunches.

The first symptoms of this rot on leafy tissues are darkened, water-soaked areas which tend to increase rapidly in size. The affected tissues soon become soft and slimy and often have a very disagreeable odor.

(See also Spinach, Bacterial Soft Rot, p. 16.)

Black Rot (Heart Rot)

(*Phoma betae* (Oud.) Frank)

Black rot sometimes affects garden beets, but it is most important on sugar beets. Usually only slight loss is caused in garden beets, but sometimes the crop is practically destroyed in fields of sugar beets. Lack of rainfall during the critical period in the life of the beet plant is particularly favorable for the development of this disease.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 33.

The pathogen often attacks seedlings and causes a serious damping-off, which is characterized by browning and blackening of the young plants just at the surface of the soil. Sometimes the fungus attacks the roots and causes blackening and shriveling, which reduce the feeding power of the root system so much that the plants become dwarfed.

On the leaves light-brown spots are formed. In the older spots the small, black fruiting bodies (pycnidia) are scattered or sometimes arranged concentrically. When the fungus gets established it may follow down the vascular bundles of the stem and enter into the crown of the root where it may cause a black, rather dry rot; this occasionally becomes serious in stored beets (pl. 1, *A*). Infections through the side or at the tip of the main root often cause extensive decay at the base of the mature beet (pl. 1, *B*). This latter type of decay is sometimes encountered on the market in garden beets. Wounds or tissues dead from other causes provide the chief points of entry into the root.

Burning of the beet rubbish which may harbor the fungus and planting only seed from healthy plants are the best methods of controlling this disease.

(See *21*, *26*, *104*, *120*.)

Cercospora Leaf Spot

(*Cercospora beticola* Sacc.)

Cercospora leaf spot is one of the most common and best known diseases of the beet. It is of direct importance from the market point of view because it disfigures the leaves, and the lesions afford points of entry for soft rot bacteria.

Small, definitely outlined spots are produced on the leaf. The margin between the diseased and the healthy tissue is reddish brown to purple, and the center of the spot is ashen gray to light tan. One of the main effects of the disease is to reduce the effective food-making area of the leaves, thus leading to the development of stunted plants with poor roots.

The causal fungus lives over from season to season mainly in old beet tops. The removal of beet trash, spraying with a 4–4–50 bordeaux mixture, and deep plowing are recommended as control measures.

(See *90*, *105*, *106*.)

Gray Mold Rot

(See Globe Artichokes, Gray Mold Rot, p. 6.)

Internal Black Spot

Internal black spot is a serious disease of garden and canning beets grown in many localities. On the market it is found on topped and stored beets, but not on young bunch beets. This trouble develops in plants grown in soils deficient in boron. It may occur in various types of soil, but it is most often serious in alkaline soils, which tend to make boron unavailable to the plants.

Internal black spot is characterized by black, irregular patches of broken-down tissue, usually in the central part of the root. The discolored areas are moist and of about the same texture as the normal tissue. They do not dry, form cavities, or cause unusual shrinkage of the root. Beets may be severely affected without showing external

symptoms of this disease. However, occasionally some tissues are affected near the surface of the root and cracks occur; these permit secondary rot-producing fungi to invade these areas.

This trouble may be avoided by applying borax to the soil. As the amount needed varies with different types of soil, the recommendations of local authorities should be followed.

(See *19*, *114*, *148*, *149*.)

Scab

(*Actinomyces scabies* (Thaxt.) Güssow)

Scab is comparatively rare on beets, but occasionally it causes appreciable damage when they are planted in heavily infested soil. The pathogen is the same as that which causes common scab on potatoes. On beets the scab lesions are superficial and much like those on potatoes except that they usually are more protruding and rounded. Affected roots are so conspicuously blemished that they are seldom offered on the market.

(See *88*.)

ENDIVE AND ESCAROLE

Endive for the market consists of the leaf heads of *Cichorium endivia* L., an annual or biennial salad plant. The leaves of commercial endive are narrow, curled, and more or less finely divided. Most of the endive shipped to the larger markets is grown in California, Arizona, and Texas. On the market endive is often called "chicory." [3]

Broadleaved varieties of endive, such as Broad Leaved Batavian, have rather thick, broad, more or less twisted and waved leaves with broad, nearly white midribs and are commonly known as escarole. The leaves of escarole are larger and more fleshy than those of the common narrow-leaved endive. Most escarole shipped to the larger markets is grown in Florida and other Southern States. It is used chiefly as a salad plant.

Diseases of importance that are found affecting endive and escarole are bacterial soft rot, bottom rot (*Corticium solani*), downy mildew (p. 9), gray mold rot (*Botrytis* sp.), watery soft rot, and two virus diseases (mosaic and yellows).

Bacterial soft rot, leaf discolorations, and watery soft rot are the most important market troubles.

(See *87*, *150*.)

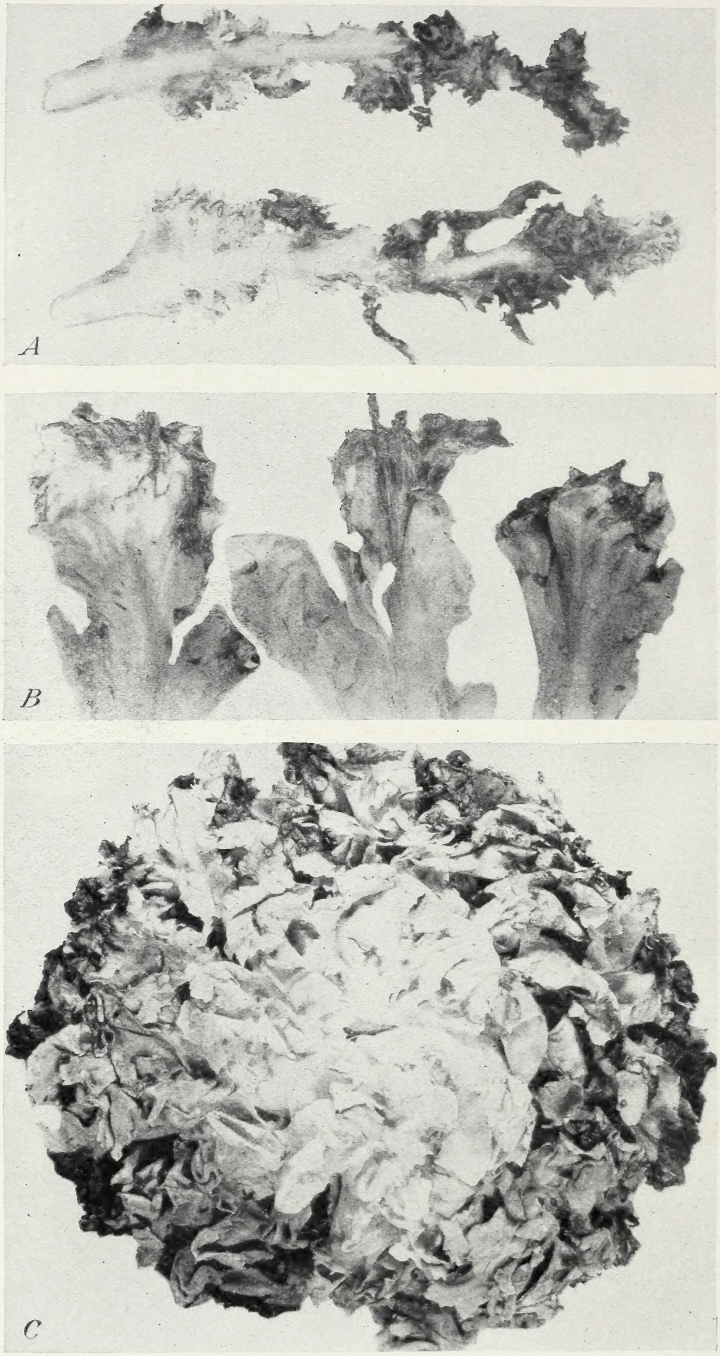
Bacterial Soft Rot

(*Erwinia carotovora* (Jones) Holland and other organisms)

Bacterial soft rot is the most important market disease of endive and escarole. The symptoms are water soaking, softening, and mushy disintegration of the affected leaf tissues.

[3] The term "chicory," as correctly used, refers to edible roots, leaves, or leaf heads of a perennial plant (*Cichorium intybus* L.) that is closely related to endive. Chicory is prepared for food in a variety of ways. Matured roots are ground, dried, mixed with coffee, and used for beverage purposes. Young roots may be boiled and served like carrots, while the young leaves are cooked and eaten like dandelions or spinach. Chicory finds its widest use as a salad plant in the form of large, slender, compact, blanched leaf heads that are grown under special conditions and marketed under the name witloof or "French endive."

Black rot of beet: *A*, Surface view; *B*, section showing internal discoloration.



A, Leaf discoloration of endive; *B* and *C*, leaf discoloration of escarole.

Most of the market decay has been attributed to the common soft rot organism (*Erwinia carotovora* (Jones) Holland). Two other bacterial pathogens (*Pseudomonas cichorii* (D. B. Swing.) Stapp and *Ps. intybi* (D. B. Swing.) Stapp), first described on chicory in this country, have since been reported as causing leaf rots of endive in Germany.

(See also Spinach, Bacterial Soft Rot, p. 16.)

(See *67*, *130*, *133*.)

Leaf Discolorations

Leaf discolorations of considerable market importance have been observed on both escarole and endive. Symptoms differ somewhat on the two types of plant. The cause of the leaf trouble is not known for either plant.

The symptoms as observed on escarole are primarily drying, browning, and partial blackening of the tip of the outer leaves (pl. 2, *B* and *C*). Ordinarily the outermost four to six whorls of leaves are found affected on the marketed leaf heads. The completely blanched center leaves have never been found affected (pl. 2, *C*). The injury usually extends ¼ to 1 inch from the leaf tip. The edges of the leaf blade are also frequently affected for an inch or two. As affected tissues dry they turn dark, curl up, become brittle, and are usually rather sharply set off from the healthy tissues. This leaf discoloration is found frequently in Florida escarole and occasionally affects a high percentage of the leaf heads.

On endive there has been found a brownish discoloration of the fringed edges and tips of the blanched heart leaves. Generally neither the green tips of the partially blanched leaves nor the outer leaves are affected. Associated with the killing of the marginal tissues is the development of tiny reddish-brown spots or streaks on the fleshy midribs (pl. 2, *A*). The discolored streaks range from one-thirty-second to one-sixteenth inch in length and are very numerous. This injury has been observed in California endive. In many instances a very high percentage of the leaf heads are affected. The limited evidence available indicates that this leaf discoloration originates during transit in refrigerated shipments made to distant markets.

Watery Soft Rot

(*Sclerotinia sclerotiorum* (Lib.) DBy. and *S. minor* Jagger)

(See Lettuce, Watery Soft Rot, p. 11.)

GLOBE ARTICHOKES

Globe artichokes for the market are the immature flower heads (buds) of *Cynara scolymus* L., a herbaceous perennial plant. The fleshy flower base or receptacle, the young flowers, and the tender base of the bracts or scales together make up the edible portion of the buds.

The globe artichoke should not be confused with the Jerusalem-artichoke (*Helianthus tuberosus* L.), which is grown for its underground tubers.

Marketability of the buds depends upon their stage of maturity, their freshness, and their freedom from disease and insect injuries. The buds must be harvested before they are too mature; otherwise the receptacle and scales will be tough and lack flavor. Toughness and drying-out may also occur in small buds produced on old plants or in buds that are held too long or in a dry place after harvest.

Of the relatively few diseases to which globe artichokes are subject the more important are gray mold rot, leaf spots (*Cercospora obscura* Heald and Wolf, and *Ramularia cynarae* Sacc.), powdery mildew (*Erysiphe cichoracearum* DC.), root rot (*Phytophthora megasperma* Drechs.), and the virus diseases mosaic and yellows.

The only market disease of significance is gray mold rot. Buds damaged by bruising, by field freezing, and by feeding of the artichoke plume moth larvae (*Platyptilia carduidactyla* (Riley)) are frequently seen on the market.

(See *70*, *141*.)

Freezing Injury

Globe artichokes freeze when exposed to temperature below about 29° F. Severe freezing kills the buds and causes them to turn black soon. Slight freezing results in breaking, cracking, and blistering of the epidermis on the exposed parts of the outer bracts. The loosened areas of the epidermis are whitish, and the bud as a whole may become somewhat browned. This detracts considerably from the market appearance of the buds.

(See *141*, *157*.)

Gray Mold Rot

(*Botrytis* sp.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Gray mold rot is at times an important field disease and is regularly the most prevalent market disease of globe artichokes. It also occurs on the market on all the other vegetables included in the present publication.

Under humid conditions the lesions of gray mold rot are moist to wet, odorless, and reddish brown or brown (pl. 3, *A* and *C*). The borders are definite and slightly water-soaked. Under dry conditions the advancing edge is not water-soaked and the affected tissues are dark brown, dry, and firm. Decay lesions can be distinguished from bruised areas by the deeper penetration of the discoloration.

Lesions may appear anywhere on the bud. Commonly they originate at the cut surface of the stem and at the tips of the bracts where splitting has occurred (pl. 3, *C*). Under humid conditions the decayed areas become covered with the grayish mycelium and the velvety, grayish-brown spore masses of the pathogen, in themselves characteristic signs of the disease (pl. 3, *B*).

CAUSAL FACTORS

Gray mold rot is caused by a species of *Botrytis* of the *cinerea* type. The fungus is found wherever vegetables are grown, since it is able to live on plants of many kinds. Spores produced abundantly under

Gray mold rot of globe artichoke: *A*, Section showing internal decay; *B* and *C*, **surface** views showing mycelium and spore masses on the decayed area (*B*) and bracts beginning to decay (*C*).

Bacterial soft rot of lettuce.

humid conditions are carried by air currents to growing plants in the field. Although wounds and other breaks in the epidermis facilitate infection the mycelium can readily penetrate moist unbroken tissues. Dead or dying tissues or those weakened by freezing or other unfavorable conditions are more readily infected than vigorous, healthy ones.

The pathogen has a wide temperature range, from about 28° to 90° F., for growth, sporulation, and spore germination. Optimum temperatures are approximately 75° to 77°. Although the fungus makes only slight growth at 28° to 32°, it is able to grow sufficiently at these low temperatures to become established in the plant tissues. It is because of this that vegetables which appear sound when removed from refrigerator cars or from cold storage may develop gray mold rot very rapidly when exposed to higher temperatures.

Moisture is much more of a limiting factor than is temperature for growth of the fungus, germination of the spores, and infection of plant tissues. The disease is therefore particularly important under conditions of moderate temperature and high humidity. Such conditions exist along the coastal districts of central California where globe artichokes are extensively grown.

CONTROL MEASURES

The only satisfactory control measure for reducing losses from gray mold rot is maintaining as low refrigeration temperatures as practicable during the transit and marketing periods. At the same time field sanitation practices and care in harvesting and packing are essential. Where artichokes are held on the market it is advisable to maintain a low temperature and as low humidity as possible.

(See *86*, *117*.)

LETTUCE

Lettuce for the market consists of the leaves or leaf heads of the lettuce plant (*Lactuca sativa* L.). Other common salad vegetables botanically related to lettuce are endive, escarole, and chicory.

There are four types of lettuce, namely, the crisphead varieties; the butterhead varieties; the cos, or romaine, varieties; and the loose-leaf, or bunching, varieties. With each type practically all the leafy part of the plant is marketed. Consequently leaf diseases, whether resulting in blemishes or decay, are factors directly affecting the marketability of the crop. Even in the crisphead types, lesions on the loose outer leaves may be important on the market for they may lead to secondary decays which spread to the inner leaves. Diseases of the roots, stems, or leaves may be indirectly important on the market through stunting of plants and production of loose heads or leaves that are poorly colored, bitter, tough, or wilted.

Lettuce is subject to many diseases the following of which are the more important: Anthracnose[4] (*Marssonina panattoniana* (Berl.) Magn.), bacterial rots, bottom rot (*Corticium solani*), brown blight, damping-off (*Pythium ultimum* Trow), downy mildew, gray mold rot, leaf spots (*Cercospora longissima* Sacc. and *Septoria lactucae* Pk.),

[4] GARDNER, M. W., and KENDRICK, J. B. LETTUCE ANTHRACNOSE IN CALIFORNIA. U. S. Bur. Plant Indus. Plant Dis. Rptr. 22 : 125. 1938. [Processed.]

powdery mildew (*Erysiphe cichoracearum*), stunt (*Pythium* sp.), tipburn, watery soft rot, and the virus diseases big vein, mosaic, spotted wilt, and yellows.

The diseases most frequently found affecting lettuce in transit and on the market are bacterial soft rot, downy mildew, gray mold rot, spotted wilt, tipburn, and watery soft rot.

(See *9*, *10*, *15*, *62*, *69*, *87*, *100*, *124*, *146*, *147*, *154*.)

Bacterial Soft Rot

(*Erwinia carotovora* (Jones) Holland and other organisms)

Bacterial soft rot is the most important market disease of lettuce. It is readily recognized by the soft, mushy consistency of the rotted tissues (pl. 4). The decay is at times confined to the outer leaves, any part of which may be affected. It commonly follows tipburn, brown blight, and spotted wilt lesions and is thus noted on some of the inner leaves.

Little has been done in the way of identifying the specific pathogens involved in the market decay of lettuce. The common bacterial soft rot organism (*Erwinia carotovora*) is capable of rotting lettuce as well as a number of other vegetable commodities. Whether *Er. carotovora* is responsible for most of the market decay of lettuce or other bacterial pathogens are of the greater importance has not been determined. Among the latter are *Pseudomonas viridilivida* (N. A. Brown) Stapp, at times the cause of a destructive field disease; *Bacterium vitians* N. A. Brown, which produces a field wilt and head decay; and *Ps. intybi*.

The shipping of lettuce free from lesions of tipburn and other diseases and the use of low refrigeration temperatures during the transit period are important means for controlling bacterial soft rot on the market.

(See also Spinach, Bacterial Soft Rot, p. 16.)

(See *13*, *14*, *83*, *129*, *130*.)

Brown Blight

Brown blight was at one time very important in the lettuce-growing districts of Arizona and California, where it was particularly destructive in the Imperial Valley. The disease has been so effectively controlled in recent years through the development and the widespread planting of the resistant Imperial strains that it is seldom seen in the field. Therefore it is unlikely that many affected heads will be found on the market. The probability that other market troubles are being confused with brown blight makes it desirable, however, to include a description of the disease in the present publication.

The cause of brown blight has not been determined, but the disease is known to be soil-borne. Once it has appeared in a field it increases rapidly with continued cropping.

On plants attacked while small the first symptom of the disease is the formation of yellow spots on the expanding leaves. All subsequently developed leaves likewise become yellowed, stunted, and flattened, thus giving the plant a rosette appearance. This is followed

A and *B*, Downy mildew of lettuce; *C* and *D*, brown blight of lettuce.

Tipburn of lettuce.

by slow browning and dying of the leaves and eventually in many cases by the early death of the plant.

The presence of brown, somewhat sunken, irregularly scattered blotches and streaks in the leaves is the usual indication of the disease on plants that are attacked after the heads have begun to form (pl. 5, *C* and *D*). Usually these lesions occur along the midribs and larger veins, with brown streaks occasionally extending into the vascular tissues of the stem. Few or many of the leaves may be affected. The lesions are usually more conspicuous on some of the outer leaves, become less so toward the center of the head, and are not found on the small heart leaves. Occasionally heads which become diseased about harvesttime appear normal externally and may be packed unintentionally for market. The symptoms on mature heads are very similar to those of spotted wilt (p. 10).

(See *60*, *61*, *64*, *142*.)

Downy Mildew

(*Bremia lactucae* Regel)

Downy mildew is of wide distribution on lettuce both under glass and in the field. It is regularly of some importance in the commercial lettuce-growing districts of coastal California and occasionally in Florida. Endive and escarole are also susceptible.

The first symptoms are light-green or yellowish spots scattered over the upper surface of the older leaves. On the lower surface of the leaves, beneath the spots, the pathogen develops as an inconspicuous white mold, which is barely visible when moist (pl. 5, *A* and *B*). Here are borne the spores of the fungus, which serve to spread the disease to other leaves and plants. Through the development of new spots and the enlargement of old ones considerable areas of the leaf may become infected, turn brown, and die. These tissues are then readily invaded by bacteria and fungi which cause secondary decays. At times when downy mildew is prevalent in the field it constitutes a serious transit and market problem. However, in recent years it has been of only minor importance on the market although it is occasionally found in small amounts on California lettuce and Florida escarole.

A number of strains of Imperial lettuce which are resistant to brown blight and which were resistant to those strains of the downy mildew pathogen that were prevalent at the time of their introduction have been developed. There has recently appeared, however, a new physiologic race of the downy mildew pathogen that will attack all the hitherto resistant lettuce strains.

(See *25*, *63*, *64*, *84*, *94*, *96*.)

Gray Mold Rot

(*Botrytis* sp.)

Gray mold rot is occasionally of some importance on lettuce both on the market and in the field. It was formerly a serious disease of greenhouse lettuce.

Affected tissues are water-soaked, somewhat grayish-green or brownish, without definite odor, and semiwatery in consistency. The characteristic grayish-brown mycelium and spore masses of the pathogen that later develop over the lesion aid in identifying the decay. In the field or greenhouse the disease resembles watery soft rot (p. 11).

The destruction of diseased plants and plant trash in the field and around the packing house and the use of low temperatures during the transit and marketing periods are the chief measures for controlling the disease.

(See also Globe Artichokes, Gray Mold Rot, p. 6.)

(See *101*, *127*, *128*, *150*.)

Spotted Wilt

Spotted wilt of lettuce has become increasingly important in some of the coastal districts of California, particularly on the late-summer and early-fall crops. It has not been found either in the Imperial Valley of California or in the lettuce-producing districts of Arizona.

The disease is caused by a virus that is transmitted from plant to plant through the feeding activities of the onion thrips (*Thrips tabaci* Lind.) and the flower thrips (*Frankliniella tritici* (Fitch)). The virus has a wide range of suscepts among which are included weeds, winter-crop plants, ornamentals, and a number of different vegetables. The disease has been reported on endive and spinach as well as on all varieties of lettuce tested. It has not been observed on globe artichokes, beets, rhubarb, or Swiss chard.

The symptoms of spotted wilt on lettuce are slight yellowing, petiole curvature, and marginal wilting of the leaves. Plants infected while young flatten out and soon die. The most conspicuous symptom on plants of all ages is the development on the leaves of brown, sunken, necrotic streaks and spots that are particularly prevalent on the lower part of the midrib (pl. 7, *A*). Any of the leaves, including the heart leaves, may be affected (pl. 7, *B*). There is thus considerable resemblance between the symptoms of spotted wilt and brown blight (pl. 5, *C* and *D*). In the case of spotted wilt, however, the plant is usually attacked on only one side and there is a pronounced curvature of affected leaves. Another important differentiating symptom is the diffuse brown discoloration of the pith and cortex that is evident upon making a fresh cut through the stem. This is usually more pronounced on one side of the plant.

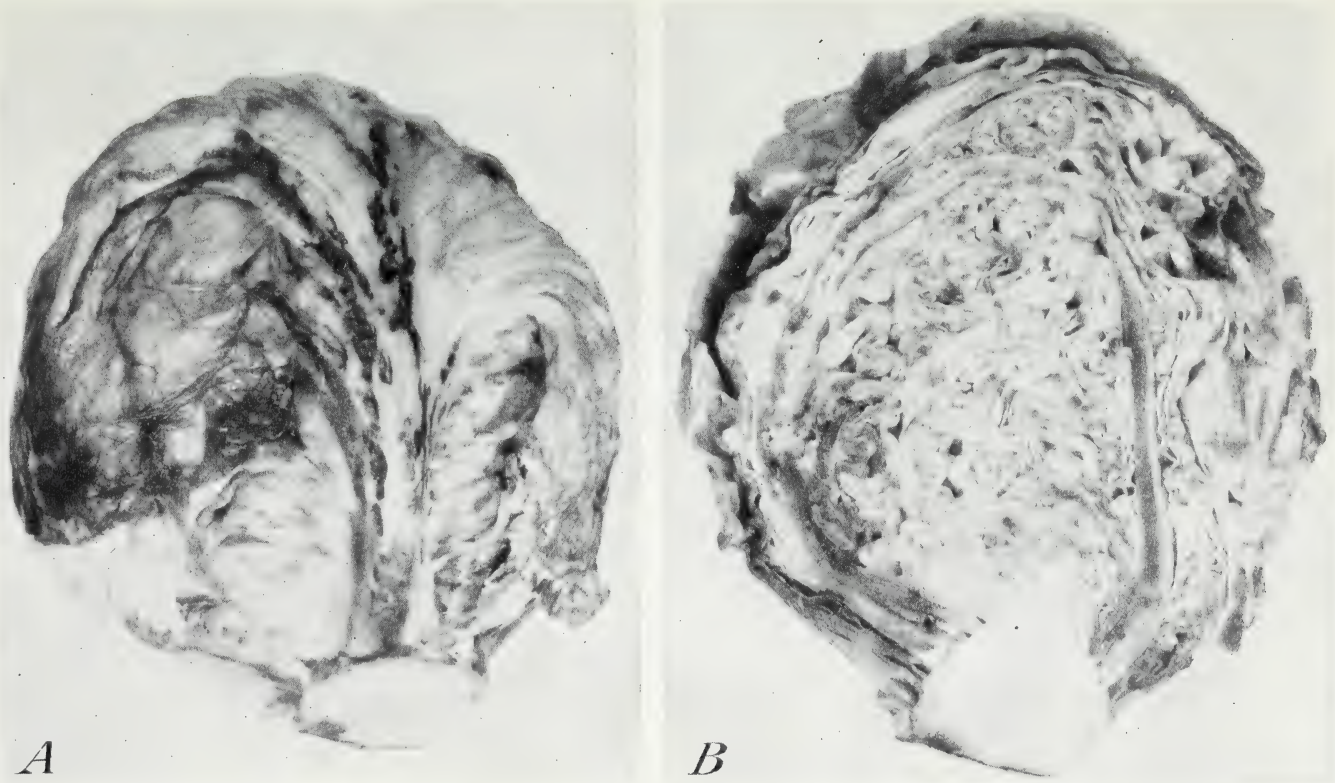
Affected heads are occasionally seen on the market, where at times the disease may have been mistaken for brown blight.

(See *27*, *28*, *29*, *33*, *142*, *145*.)

Tipburn

Tipburn is a physiologic disease that is found wherever lettuce is grown. It is of considerable importance on the market.

As suggested by the name, the disease is characterized by a burning or dying of the leaf tissues. Tipburn ordinarily does not affect the older outer leaves but is confined to the more actively growing inner ones. Thus it is not always apparent from the outside of the head.



Spotted wilt of lettuce: *A*, Surface view; *B*, section through head showing internal discoloration of leaves.

Although it may extend well into the head, usually the youngest leaves in the center are not affected.

The first symptom is the appearance of small, yellowish, translucent areas or spots near the leaf margins. As these enlarge and become more numerous the tissues near the edge of the leaf wilt, turn brown, and die, thus forming an irregular brown border along the edge of the leaf (pl. 6). Darkening of the veins in the affected areas usually occurs. The diseased tissues may dry out somewhat and curl up or they may remain moist. They frequently are later infected with soft rot bacteria (p. 8) and become slimy.

Tipburn is apparently brought on by a too-rapid loss of water from the leaves. However, just what combination of environmental factors is responsible for this is not fully understood. The disease is known to be much more prevalent at high temperatures. Hot, dry, sunny weather following cloudy, rainy periods is commonly believed to favor the appearance of the trouble. Losses are greatest in lettuce that is nearing maturity. There is some evidence that tipburn may increase in severity during the transit and market period.

Maintenance of a uniform supply of soil moisture, the use of good cultural methods, and care in the application of fertilizer are all recommended as control measures. In California, planting is so arranged as to avoid the maturing of crops during the hottest weather; during such periods lettuce is grown in the cooler coastal districts rather than in the hotter valleys of the interior. Some progress has been made in developing partially resistant varieties.

(See *55*, *82*, *99*, *118*, *122*, *128*, *129*, *143*, *144*.)

Watery Soft Rot (Sclerotinia Rot)

(*Sclerotinia sclerotiorum* (Lib.) DBy. and *S. minor* Jagger)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Watery soft rot is commonly found affecting a wide variety of vegetables under transit, market, and storage conditions. It is frequently of market importance on lettuce, endive, and escarole. Formerly, when lettuce was produced extensively under glass, losses from sclerotinia rot, or lettuce drop, or wilt, as it is also called, were very serious. Under field conditions lettuce drop at times causes important losses wherever the crop is grown.

As is indicated by the name, the chief symptom is the development of a soft, watery decay that usually is first evident on the stem and lower leaves near the soil surface. From there it may progress downward, killing the roots or upward into the center of the plant, affecting the bases of the leaves. As this takes place, the leaves progressively wilt and collapse. The outer part of the plant shrivels and dries; the central part may be converted into a soft, wet, rotten mass.

On the market the decay may be found anywhere on the head, although it usually occurs at the basal part. Affected tissues are water-soaked, light or pinkish brown, and without a characteristic odor. In advanced stages they collapse to form a wet, leaking decay. The presence of the cottony, white mycelium of the pathogen aids in identifying the rot. Another characteristic sign is the scattered de-

velopment of the irregular, bluish-black to black resting bodies or sclerotia of the fungus.

CAUSAL FACTORS

The fungus *Sclerotinia sclerotiorum* is the chief pathogen, but at times *S. minor* is responsible for the decay. These fungi are perpetuated from crop to crop as sclerotia either in the soil or in refuse from previously diseased plants. When favorable conditions of temperature and moisture prevail, the mycelium grows from these into the soil and attacks plants of the current crop. The pathogen is also spread by means of innumerable spores produced in little cup-shaped fruiting bodies (apothecia) that push up to the surface of the soil from buried sclerotia. Here the spores are released and are carried by air currents to healthy plants.

Growth of the mycelium, germination of the sclerotia, production of the apothecia, and infection of the plants all occur only under moist conditions. Production and discharge of spores are favored by moderately low temperatures and prevented by those above 80° F. Each species of *Sclerotinia* has a wide temperature range for growth and decay production. Infection may occur at temperatures as low as 32° to 34° and as high as 82°. A range of approximately 70° to 78° is most favorable.

The presence of fresh wounds, although not essential for entrance of the pathogen, favors early infection. When temperatures become high during transit or packages are held unusually long on the market or in storage spread of the fungus from head to head may occur.

CONTROL MEASURES

The first step in controlling market losses from watery soft rot is to reduce the disease in the field. Where feasible, it is advisable to destroy diseased plants and plant trash in which the fungus may continue to develop and produce sclerotia. Studies have indicated that after-harvest pasturing of lettuce fields with livestock, particularly sheep, may be helpful in this connection. It has been shown, however, that livestock fed on diseased refuse from packing houses may, through evacuation of viable sclerotia, spread the fungus to uninfested fields. A quarantine period of 4 days is therefore recommended for sheep that have been pastured in infested fields or fed on diseased lettuce trash.

The disease can be controlled in seedbeds and greenhouses by disinfecting the soil with formaldehyde.

The maintenance of low temperatures, although not completely checking the disease, constitutes the most important measure for controlling watery soft rot in transit and on the market.

(See *6*, *11*, *12*, *59*, *68*, *115*, *132*, *150*.)

RHUBARB

Rhubarb (*Rheum rhaponticum* L.), sometimes called pieplant, is grown for its thick, fleshy leafstalks. The marketability of these depends largely upon tenderness and crispness, which are a matter of age, and upon freedom from blemishes and decay. There are a

few diseases which affect the leaves of the plant in the field and some that attack the leafstalk directly. The leaf spots (*Ascochyta rhei* Ell. and Ev., *Cercospora* sp.) and rust (*Puccinia phragmitis* (Schum.) Körn.) are relatively unimportant compared with anthracnose, crown and foot rots, rhizoctonia rot (*Corticium solani*), and stem spot which affect the leafstalks.

Bacterial soft rot and gray mold rot are the most important diseases of rhubarb on the market.

(See *4*, *7*, *16*.)

Anthracnose

(*Colletotrichum erumpens* Sacc.)

Anthracnose has been found on rhubarb in the field in several localities and on the market, where it is especially damaging because the lesions detract from the appearance of the product and sometimes open the way for secondary decay-producing organisms.

Anthracnose is characterized by soft, watery, and translucent spots on the leafstalks, which are the only part of the plant affected. The lesions are usually oval in outline, with the long axis lengthwise of the stalk. When a lesion attains a diameter of about one-half inch very small, black specks (spore-producing acervuli) appear in great numbers in the center of the spot. In advanced stages the whole stalk is soft and rotten and covered with acervuli. This complete decay is most often found in old, wilted stalks in the fields. Only the small spots which escape the notice of the packer are found on the market.

The pathogen produces innumerable spores in the acervuli. These spores are spattered by raindrops or are carried by insects from one stalk to another. In moist, rather warm weather infection and development of decay may take place in a short time. Wounds are not necessary for infection; consequently there is a possibility of the disease spreading by contact if infected stalks are packed with healthy ones.

No control methods have been developed.

(See *131*.)

Bacterial Soft Rot

(See Spinach, Bacterial Soft Rot, p. 16.)

Gray Mold Rot

(*Botrytis* sp.)

Gray mold rot is the most serious transit and market disease of rhubarb. Although the causal fungus is practically ever present wherever this crop is grown, it seldom affects vigorously growing plants in the field. However, injured plants and old leaves become infected readily under humid conditions. The causal fungus produces great numbers of spores, which contaminate the leafstalks during harvesting and packing.

On the market gray mold rot in the early stage appears as small red spots on the sides of the leafstalk (pl. 8, *A*) and as water-soaked brown areas at the base of the stalk or in injured tissues elsewhere.

At this stage no mycelium or spores are visible. Decay lesions enlarge rapidly, soon involving large portions of the stalk. Grayish, smoke-colored mycelium and grayish-brown, granular masses of spores on the larger lesions are characteristic signs of this disease (pl. 8, *B*). Most infections take place at the bases of the leafstalks where wounds are made in harvesting, but they may also occur in apparently normal tissue.

Refrigeration temperatures of 40° to 45° F. will retard but not stop the development of gray mold rot during transit.

(See also Globe Artichokes, Gray Mold Rot, p. 6.)

Phytophthora Rots (Foot and Crown Rots)

(*Phytophthora* spp.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

In all regions where rhubarb is grown commercially apparently one or more species of *Phytophthora* may cause serious diseases. Although different organisms are involved as causal agents the disease symptoms produced are very similar and for practical purposes may be considered as characterizing one disease.

The phytophthora diseases, often referred to as foot and crown rots, are primarily field troubles, but occasionally infected stalks reach the markets. Bacterial soft rot follows these rots so closely that by the time diseased stalks reach the market the former appears to be the more important decay. For this reason these two diseases often have been confused on the market.

The first indication of phytophthora rots usually is the wilting of a few leaves. A watery, greenish-brown, sunken lesion at the base of the leafstalk indicates the point of invasion by the causal fungus. A rapid decay follows infection, and the stalks may collapse within 24 hours. The pathogen progresses from the diseased stalks into the roots, causing a brown decay, and from there spreads upward into other stalks and buds. Secondary bacterial infections usually cause immediate decomposition of affected plants.

CAUSAL FACTORS

The pathogens responsible for most of the foot and crown rots of rhubarb are *Phytophthora parasitica* Dast. and *P. cactorum* (Leb. and Cohn) Schroet. However, a closely related fungus, *Pythium ultimum*, and other species of *Pythium* have also been found to cause serious root, crown, and stalk rots in some localities. All these fungi produce swimming spores (zoospores), and for this reason the severity of infection is directly correlated with the amount of rainfall. Warm, wet weather is especially favorable for the development of the foot rot caused by *Phytophthora parasitica*, since it grows best at about 86° F. The minimum temperature for growth of this fungus is 55° and the maximum 97°. *P. cactorum*, which commonly causes crown rot, is more likely to be found farther north or to occur during cool, wet seasons. Its minimum temperature for growth is 43°, the optimum 77°, and the maximum 92°.

Infections by any of these organisms may take place in uninjured as well as injured stalks.

Gray mold rot of rhubarb: *A*, Early stage; *B*, advanced stages.

A and *B*, Downy mildew of spinach: *A*, Upper surface of leaf; *B*, lower surface of leaf showing mycelium and spores on old spots. *C* and *D*, Bacterial soft rot of spinach. Note characteristic discolorations in medium (*C*) and advanced (*D*) stages.

CONTROL MEASURES

The best control for phytophthora rots is obtained by making sure that only healthy roots from fields free from disease are used when new plantings are made. Roots showing any internal discolorations should not be planted, and soil known to be infested should be avoided.

The spraying of young plants and the soil about the crown of the root with bordeaux mixture (4–4–50) before the disease appears has been recommended as one means of control.

Although no data are available regarding the development of decay during transit, the possibility of such decay occurring makes it undesirable to pack for shipment any rhubarb showing any evidence of infection.

(See *5*, *31*, *95*.)

Stem Spot (Leaf Spot)

(*Phyllosticta straminella* Bres.)

This stem and leaf spot disease is sometimes of market importance on Illinois and California rhubarb. The leaf spot stage is found on the young as well as the old leaves. Small, greenish-yellow spots on the upper surfaces of the leaves indicate the first stages of infection. As these spots enlarge they become tan, with wine-red borders. Eventually portions of the dead tissues drop out, leaving ragged holes. When the stems are infected the most serious loss generally occurs in the first cuttings. Stem lesions are characterized by small, oval to oblong, reddish-brown spots. With age some of these may become elongated and extend one-half inch or more lengthwise of the stem. In both the leaf and stem spots small, black fruiting bodies (pycnidia) eventually appear in the dead tissue. The presence of these black pycnidia generally serves to identify this disease. In some instances *Botrytis* sp. and secondary fungi, such as *Rhizopus*, *Cladosporium*, and *Penicillium*, invade stem spot lesions.

Experimental work has shown that infection may occur in healthy, uninjured tissue wherever the fungus comes in contact with moist stems. However, it appears that the development of lesions takes place so slowly that no new spots would develop during transit.

In most localities this disease probably can be controlled by removing the infected leaves as soon as the disease is detected and by destroying dead leaves and stems at the end of the season so that the fungus will not be harbored in the plant refuse.

(See *125*, *131*.)

SPINACH

Spinach for the market consists of the leaves and crown of the plant (*Spinacia oleracea* L.). It should be of good green color, fresh, crisp, and free from blemishes and decay.

The more important diseases that affect spinach are anthracnose (*Colletotrichum spinaciae* Ell. and Halst.), bacterial soft rot, damping-off (*Pythium ultimum*), downy mildew, heterosporium leaf spot, other leaf spots (*Cercospora beticola*, *C. flagelliformis* Ell. and Halst., and *Phyllosticta chenopodii* Sacc.), rust (*Puccinia aristidae* Tracy), white rust, wilt (*Fusarium* spp.), and the virus diseases cucumber mosaic (blight or yellows), beet mosaic, curly top, and spotted wilt.

On the market bacterial soft rot, downy mildew, heterosporium leaf spot, and white rust are the diseases most frequently observed.

Damage to the young leaves in the center of the plant caused by feeding of the larvae of the seed-corn maggot (*Hylemya cilicrura* (Rond.)), the so-called budworm injury, and the holes made in the older leaves by feeding of the spotted cucumber beetle (*Diabrotica duodecimpunctata* (F.)) constitute important insect injuries noted on the market.

(See *3*, *15*, *56*, *57*, *89*, *103*, *123*, *140*.)

Bacterial Soft Rot

(*Erwinia carotovora* (Jones) Holland and other organisms)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Bacterial soft rot is one of the most important diseases of vegetables. It affects a wide variety of different commodities causing losses in the field and serious spoilage of the marketed products. Bacterial soft rot is an important market disease on beets, endive, escarole, lettuce, and spinach among the vegetables included for discussion in the present publication.

Affected tissues become water-soaked, muddy green, or greasy in appearance (pl. 9, *C* and *D*). Rapid softening and disintegration follow so that the decayed tissues soon become wet and mushy. Under moist conditions favorable for development of the rot, the leaf may be completely destroyed and have a putrid odor. In dry air the decay may be checked and the affected tissues become dry and brittle.

CAUSAL FACTORS

Bacterial soft rot of vegetable commodities is caused by *Erwinia carotovora* and other bacterial organisms. These bacteria are found commonly in soils and plant debris. They are spread by contact with farm animals, tools, and insects and by running or splashing water. The market product becomes contaminated with the soft rot bacteria while in the field or during harvesting and packing operations. Insect punctures and other wounds, disease lesions, or other skin breaks are essential for entrance of the pathogen.

A combination of high humidity and high temperatures is ideal for the reproduction of the bacteria and the development and spread of the decay. Under humid conditions the most favorable range is approximately 77° to 86° F. Frequently the decay is more important at somewhat lower temperatures (69° to 77°), inasmuch as at these temperatures there is less drying-out than at the higher range. The decay is checked by temperatures of about 40° to 45°.

CONTROL MEASURES

The control of transit and market losses caused by bacterial soft rot consists very largely in maintaining low temperatures during transit and moving the commodity promptly through marketing channels after it is unloaded.

Shipping fresh, high-quality produce that is as free as possible from disease lesions, as well as reduction in the crushing and bruising

of the harvested product, will do much to reduce losses from this decay.

(See *32*, *66*, *85*, *116*, *117*, *126*.)

Downy Mildew

(*Peronospora spinaciae* Laub.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Downy mildew is found throughout all the commercial spinach-growing areas of the country. Field losses of significance occur regularly and during some seasons may be very extensive. On the market it constitutes one of the most prevalent and important diseases of spinach. The leaf blemishes detract from the appearance and quality of the marketed product and, when in an advanced stage, frequently afford ready infection courts for secondary soft rot bacteria.

The appearance of pale-yellow areas in the normal green of the leaf usually constitutes the first symptom of the disease. These areas or spots are irregular in shape, are without clearly defined margins, and vary considerably in size (pl. 9, *A*). They are apparent on both upper and lower leaf surfaces. Under humid conditions the pathogen develops over the surface of the infected areas on the lower side of the leaf as a downy gray mold that soon turns lilac gray or purple gray (pl. 9, *B*). Symptoms vary with humidity. Thus, under very low relative humidity yellowing may occur without any signs of the pathogen appearing, while under high humidity the downy mildew may develop before there is any evidence of yellowing. Under very humid conditions the pathogen may occasionally be found fruiting on the upper leaf surface and the petioles. Lower leaves are frequently the first to be infected. Severely infected leaves may dry up or under wet conditions become water-soaked and brownish and soon decay.

There is some evidence that new spots may appear and old ones become more prominent during the transit and marketing periods.

CAUSAL FACTORS

The pathogen, *Peronospora spinaciae*, is one of the downy mildew fungi and can grow and reproduce only while associated with living tissue. Only spinach is attacked. The fungus reproduces primarily by means of the conidia, or summer spores, which form in great abundance under humid conditions (relative humidity of 85 percent or above). It is the presence of conidia and of the conidiophores on which they are borne that gives the mildew the purplish-gray color.

The conidia are splashed from leaf to leaf by rain and are carried from plant to plant by winds, insects, or other agencies. The presence of surface moisture is necessary for germination of the conidia. The temperature range through which infection may occur is 40° to 75° F. with an optimum temperature for germination of the conidia of about 48°. At temperatures of 60° to 65° infection of spinach leaves may occur within 3 hours after they are inoculated. Fruiting of the fungus on these new lesions may take place 6 days after inoculation.

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Oospores, or resting spores, are produced in diseased leaf tissue and have been found mixed with the seed. It has not been determined, however, just how important a role they play in the life history of the fungus.

CONTROL MEASURES

Although copper protectants are toxic to spores of the downy mildew pathogen their use has not been found practicable under commercial conditions. There is little evidence to suggest that the disease can be controlled through development of resistant varieties of spinach. Because of circumstantial evidence that the disease may originate in a field through use of infested seed, it is possible that some measure of control may be obtained by use of seed from a disease-free field. Under Long Island, N. Y., conditions the most important method of control found was reducing the primary inoculum by separating overwintered spinach from winter and spring plantings.

(See *17*, *24*, *71*, *81*, *121*.)

Heterosporium Leaf Spot

(*Heterosporium variable* Cke.)

Heterosporium leaf spot, although widely distributed, is ordinarily of only limited commercial importance. The causal fungus is usually considered to be only weakly pathogenic and to attack plants that are already of low vigor as the result of unfavorable environmental conditions, infection of downy mildew, or other diseases. On the market it is occasionally found as a conspicuous blemish of Virginia and Texas spinach.

The disease may be identified by the presence of numerous small, circular, light-brown, slightly depressed spots that average from one-sixteenth to one-eighth inch in diameter (pl. 10, *C*). They have sharply defined borders and are evident upon both the upper and the lower surface of the leaf. The pathogen appears as an abundant olive-green to black sporulating mold that covers the older spots on both leaf surfaces. Where spots are numerous they coalesce and the adjacent uninfected areas of the leaf may become yellowed and then turn brown. Spots are most abundant on the older leaves.

No specific control measures are known.

(See *30*, *65*, *119*.)

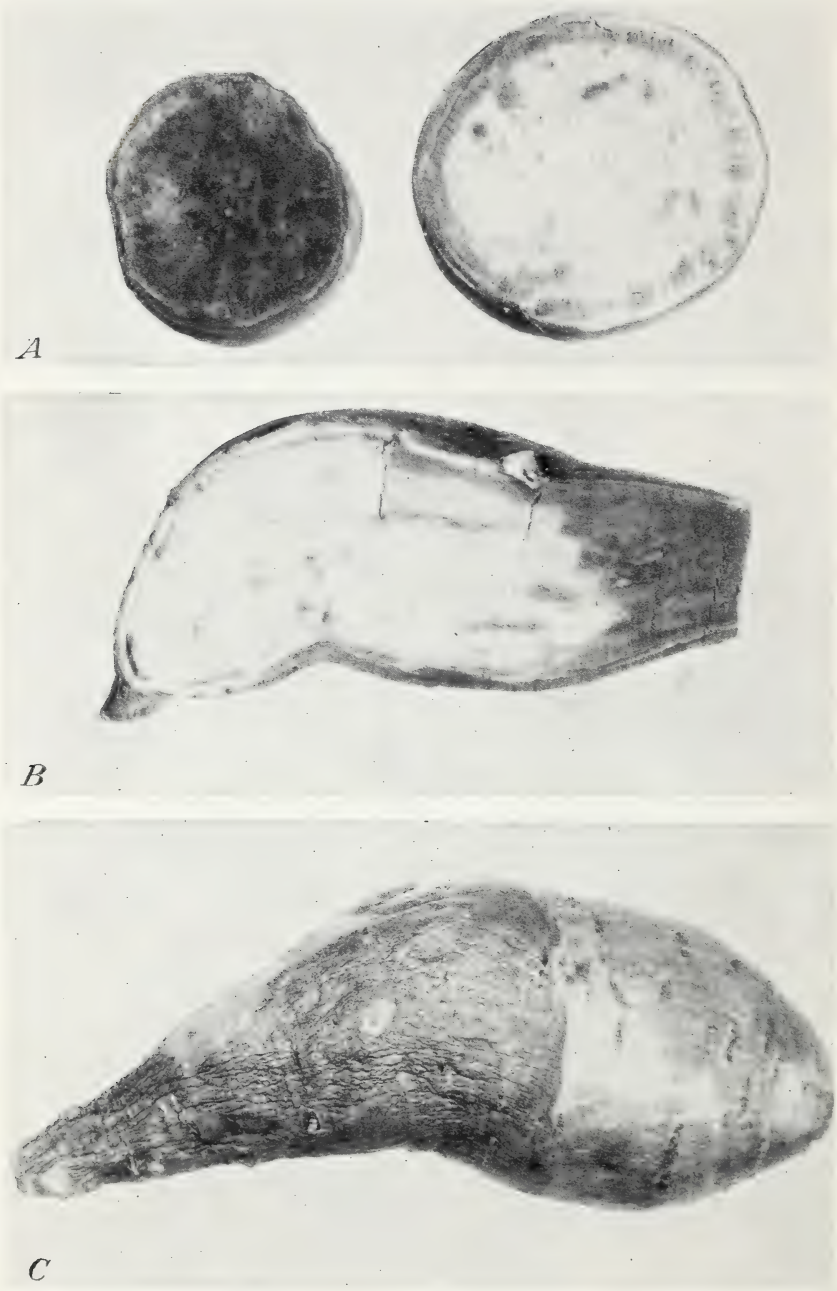
White Rust

(*Albugo occidentalis* G. W. Wils.)

White rust is at times a serious disease of spinach in the Winter Garden district of Texas where it first appeared in destructive form in 1937. The disease has also been found in Oklahoma and Arkansas. On the market, white rust is one of the important diseases of Texas spinach.

The pathogen develops within the leaf tissues and later produces on the lower leaf surface numerous tiny blisterlike pustules (sori), which are filled with whitish masses of spores (pl. 10, *A*). These fruiting structures of the fungus in themselves serve to identify

A and *B*, White rust of spinach; *C*, heterosporium leaf spot of spinach.



Charcoal rot of sweetpotato: *A* and *B*, Sections showing internal discolorations; *C*, surface view.

the disease. Accompanying the white sori is a slight yellowing of the adjacent areas that is apparent on both surfaces of the leaf. The yellowed areas are indefinite in outline and when seen from the upper side are somewhat similar to those on leaves affected with downy mildew. White rust usually appears first near the borders of the outermost leaves of the plant (pl. 10, *B*). Later the under surfaces of all leaves may bear a few to many sori. Occasionally a few sori are found on the upper surface. Leaves that are severely infected may show brown, necrotic spots and the entire leaf may later turn brown.

There have been no adequate measures developed for controlling white rust.

(See *58*, *155*.)

SWISS CHARD

Swiss chard (*Beta vulgaris* var. *cicla* L.), a close relative of beets, is grown for its stalks and leaves, which are used as greens. Bacterial soft rot (p. 2) and cercospora leaf spot (p. 3) are the most common diseases of this crop in transit and on the market.

SWEETPOTATOES

The sweetpotato of commerce consists of the thickened roots of the sweetpotato plant (*Ipomoea batatas* (L.) Lam.). There are a great number of varieties but only about a dozen are important for food in the United States. These can be divided into two general types, viz, the dry mealy kinds, such as the Yellow Jersey, and the moist fleshy ones, such as the Nancy Hall. The former are preferred generally in the northern markets and the latter in the markets of the South. Regardless of variety the roots should be firm, smooth, well-shaped, and free from blemishes and decay.

Many diseases which attack plants in the field not only lead to reduction in yield but also may affect the quality of the crop by causing production of poorly shaped, poorly colored, rough, undersized, or blemished potatoes. Some of the diseases which affect the growing plants also cause blemishes and decay of the roots during storage and marketing.

The most important diseases which affect the growing plant are black rot, foot rot, mottle necrosis, Texas root rot (*Phymatotrichum omnivorum* (Shear) Dugg.), sclerotium rot (*Sclerotium rolfsii* Sacc.), soil rot, and stem rot, or wilt. Scurf and rhizoctonia rot (*Corticium solani*) affect the skin of the roots, making them unsightly and impairing their keeping qualities.

The following diseases lead to losses of sweetpotatoes in storage and on the market by causing blemishes and decay: Alternaria rot (*Alternaria* sp.), black rot, blue mold rot, charcoal rot, dry rot, epicoccum rot (*Epicoccum* sp.), end rots, foot rot, gray mold rot, Java black rot, mucor rot, rhizopus soft rot, sclerotinia rot (*Sclerotinia sclerotiorum*), scurf, soil rot, surface rot, and trichoderma rot (*Trichoderma koningi* Oud.). Many of the storage diseases are less serious if sweetpotatoes are cured for 10 days to 2 weeks at 85° F. and a relative humidity of 85 to 90 percent and subsequently stored at 50° to 55° and a relative humidity of 80 to 85 percent.

The most important nonparasitic troubles are bruising injury, chilling injury, freezing injury, growth cracks, and internal breakdown.

(See *2*, *18*, *35*, *46*, *47*, *75*, *79*, *93*, *98*, *107*, *108*, *135*, *138*, *151*, *152*.)

Black Rot

(*Ceratostomella fimbriata* (Ell. and Halst.) Elliott)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Black rot is one of the most serious and most widely distributed diseases of sweetpotatoes. Although it injures the plants in the seedbed and in the field, most damage is caused in storage and during marketing. Next to rhizopus soft rot it is the most serious market disease of sweetpotatoes.

The early stages of black rot appear as circular, brown, slightly sunken, superficial spots about one-fourth inch in diameter. As these spots enlarge (½ inch to 2 inches) they become black to greenish black and frequently show small, black fruiting bodies (perithecia) with long necks, which appear to the naked eye as black bristles (pl. 12). Even in advanced stages the rot is firm and generally shallow, rarely penetrating to the center of the root. The internal tissues are black or greenish black. The diseased tissues are very bitter, and the entire root when cooked has a bitter flavor.

In the seedbed this disease frequently causes serious damage to the sprouts. Plants developing from infected sprouts appear yellowish and sickly, and the most severely diseased ones die. Those that do not die may produce a crop of infected roots that will rot in storage or during marketing. On account of the black lesions produced on the slips and on the plants in the field the disease is often called black shank.

CAUSAL FACTORS

The causal fungus (*Ceratostomella fimbriata*) is carried over from season to season in roots, plant debris, and soil. Diseased roots bedded for slips often carry the disease into the field. However, roots and the slips arising from them may become infected from infested soil in the seedbed or the field. This disease is favored by wet soil and moderately high temperatures. The fungus will grow throughout a temperature range from 50° to 95° F., but most rapid growth takes place at about 77°. Sweetpotatoes may become infected through wounds, dead rootlets, or apparently uninjured tissues. The number of infections depends upon the soil-moisture and temperature conditions previous to and during harvesting. Although the obviously infected potatoes are discarded at storage time, during seasons of heavy infections a great many potatoes will have numerous small spots too small to be graded out. Under storage conditions these small spots may enlarge to about 1 inch in diameter within 4 to 6 weeks. This is usually the explanation for rather high percentages of black rot appearing in sweetpotatoes that were thought to be free from decay when they were stored. Furthermore, the spores of the fungus may be carried by insects, rodents, and air currents or

Black rot of sweetpotato, showing various stages of external and internal decay.

through handling or washing; thus additional infections may take place through wounds during storage and transit. For this reason sweetpotatoes from an infested field should not be stored with those from a disease-free field.

CONTROL MEASURES

Experimental evidence indicates that none of the commercial varieties of sweetpotatoes is resistant to black rot. To avoid the development of this disease in the field, great care should be exercised in selecting disease-free roots for seed purposes. Such roots should be disinfected by immersing them for 10 minutes in a solution made by dissolving 6 pounds of borax in 30 gallons of water. Infested soil should be avoided in the field and the hotbed.

Control in storage involves careful inspection and discarding of all infected sweetpotatoes previous to storing and keeping those that are harvested from soils known to be infested separate from those grown in disease-free fields. For recommended curing and storage conditions, see page 19. Careful handling to avoid wounds in preparing the sweetpotatoes for market is always advisable. Washing the potatoes may spread the disease.

(See *23*, *49*, *50*, *73*, *97*, *134*.)

Blue Mold Rot

(*Penicillium* sp.)

Blue mold rot is most often found in sweetpotatoes that have been chilled or frozen. Potatoes that have been stored at low temperature and moderately high humidity are particularly susceptible.

The spores of the causal fungus are ever present in the air and on the surface of most fruits and vegetables, but they are unable to cause infection except through wounds or through tissues broken down by other agencies.

Blue mold rot is a soft decay generally involving large areas about mechanical injuries or lesions of other diseases. In chilled or frozen sweetpotatoes the whole root is soon decayed and the characteristic white and blue-green tufts of mold break through the epidermis. These colored tufts are the most reliable diagnostic character. When many potatoes are infected the whole lot has a musty odor.

This disease may be avoided if care is used to prevent injury in handling the sweetpotatoes and if proper temperature and humidity are maintained (p. 19). It is especially important that a combination of low temperature and high humidity be avoided.

(See *46*.)

Charcoal Rot

(*Sclerotium bataticola* Taub.)

Although charcoal rot is most important as a storage disease of sweetpotatoes, it sometimes causes injury to growing plants in the field when the stem becomes infected at the soil line. From the diseased vine the causal organism grows down to the roots and to the developing sweetpotatoes. Decay most often starts at the upper

end of the sweetpotato and progresses throughout its length from that point. In the early stages charcoal rot is characterized by a light-brown discoloration of the surface as well as of the internal tissues. The discolored areas may be of any size or shape, but there is a sharp line of demarcation between the diseased and healthy tissues (pl. 11, *C*). As the decay progresses, the affected regions remain firm and become dark brown. The skin later begins to shrivel as water is lost by evaporation. In the final stages of this disease the root is converted into a hard, dry, charcoallike mummy.

When a decaying potato is cut there are usually three rather distinct color zones in the affected tissues. The margin or advancing edge of the decay is light or cinnamon brown and slightly spongy in texture, the intermediate zone is reddish brown and firm, and the oldest part of the lesion (end of sweetpotato or center of decayed spot) is grayish black to black, dry, and firm (pl. 11, *B*). On close examination of the grayish-black region very small, black, specklike sclerotia may be seen within the tissues (pl. 11, *A* and *B*). No sclerotia or fungus filaments are visible on the surface of diseased sweetpotatoes.

This disease progresses slowly in storage, but in freshly harvested stock having slight infections at the ends of the roots decay develops rapidly. By the time some shipments of new stock reach the market as many as 50 percent of the sweetpotatoes show charcoal rot.

Sweetpotatoes showing even the slightest decay at the ends at harvesttime should not be stored or shipped. If they are to be stored they should be handled carefully, for infections may take place through wounds and extensive rots develop later in storage and during marketing.

Experimental evidence indicates that the minimum temperature for growth of the causal organism is near 46° F., the optimum 88°, and the maximum 108°.

Wounded sweetpotatoes immediately stored at 55° F. in low humidity have been found much more likely to decay than those properly cured and then stored (p. 19). Under the latter conditions the wound-cork formation develops more rapidly and thus prevents infection.

(See *46*, *134*, *135*.)

Chilling Injury (Low-Temperature Break-Down)

The sweetpotato is subject to chilling injury when stored for some time (10 days or longer) at temperatures ranging from its freezing point (28.5°) to about 50° F. This low-temperature break-down is brought about by physiologic changes that occur within this temperature range. The chief symptom is an internal discoloration found as scattered areas and specks associated with the vascular ring and with the vascular elements in the central part of the sweetpotato.

Storage under conditions conducive to chilling injury makes sweetpotatoes particularly subject to spoilage by a number of different rots including mucor rot, blue mold rot, and gray mold rot. These often cause serious loss within 3 to 6 weeks when sweetpotatoes are stored at about 32° to 45° F.

The danger from chilling and from the decays associated with it make it hazardous to expose sweetpotatoes to storage temperatures below 50° F.

(See *46*, *74*.)

Dry Rot

(*Diaporthe batatatis* (Ell. and Halst.) Harter and Field)

Dry rot is widely distributed but seldom causes serious trouble on sweetpotatoes in the field. From infections on slips in the seedbed and diseased vines in the field the causal fungus invades the potatoes at the attached ends. Most losses from this disease occur during storage and marketing.

Dry rot even in early stages is characteristically a dark-brown, firm decay. In practically all cases it starts at the end of the potato. As the fungus progresses, the broken-down tissues lose water quickly and a withering of the affected end results. Soon the diseased area becomes black and hard. The surface of such areas is soon covered with black pimplelike elevations, the fruiting bodies (pycnidia) of the causal fungus (pl. 13, *A*). These numerous black pimples in and underneath the skin of a sweetpotato showing a dry, hard, black decay generally serve to identify this disease.

Dry rot does not develop as rapidly or cause as much loss as black rot, but inoculation experiments show that infected sweetpotatoes may be completely rotted within about 6 weeks at the usual storage temperatures.

No definite control methods have been worked out. Seedbed sanitation and careful selection of seed stock appear to be satisfactory control measures in most localities.

(See *38*.)

End Rots

(*Fusarium* spp.)

Although end rots may be caused by a number of different organisms that under special conditions attack sweetpotatoes, most of those encountered on the market are caused by species of *Fusarium* distinct from those responsible for surface rot (p. 32) and for stem rot (p. 31). They commonly invade the sweetpotato through wounds and through tissues that are broken down by other agencies. Consequently these fusarium end rots frequently show a wide variety of symptoms. The most serious type found on the market is a firm, dry rot characterized by a withering of the ends of the sweetpotatoes (pl. 13, *B*).

(See *156*.)

Foot Rot

(*Plenodomus destruens* Harter)

Foot rot of sweetpotatoes is one of the diseases that is sometimes important as a field disease as well as a storage and market trouble. It has been found to be widely distributed, but it usually causes less damage than black rot and other field troubles. In the field, foot rot causes stunting and blighting of the vines with attendant reduction in

yield. Severe early infections may cause death of plants. Infected sweetpotatoes from diseased vines carry the fungus into the storage houses where decay progresses, often causing serious loss.

In storage and on the market foot rot appears as a firm to spongy, dark-brown decay with evident shriveling of the affected tissues (pl. 14, *A*). Most lesions soon show numerous dark-brown fruiting bodies (pycnidia) in the skin of the sweetpotato near the end. Practically all infections take place at the attached end of the sweetpotatoes during the growing season, but infections have been observed to occur in wounds made at harvesttime. Although this decay is somewhat similar to black rot it does not become as black, and the pycnidia do not have the long bristlelike necks that characterize the latter disease. Furthermore, the fact that almost all foot rot occurs at the ends of the sweetpotatoes is often an aid in distinguishing between these two diseases.

The principal source of foot rot infection of plants is in the seedbed. The causal fungus may live over in plant debris in the field and attack slips after they are set out, but most of the infection results from carrying the fungus into the field on diseased slips produced on infected seed sweetpotatoes. Although the fungus has a tendency to grow upward through the stem it often progresses downward to the roots. This results in decay starting at the end of the sweetpotato. At digging time the decay is often so slight as to make it impossible to sort out all diseased sweetpotatoes before they are stored. It is such mildly infected sweetpotatoes that cause trouble in storage and transit.

Foot rot is a slowly developing decay favored by temperatures between 68° to 86° F. Little growth of the fungus occurs below 54° or above 98°.

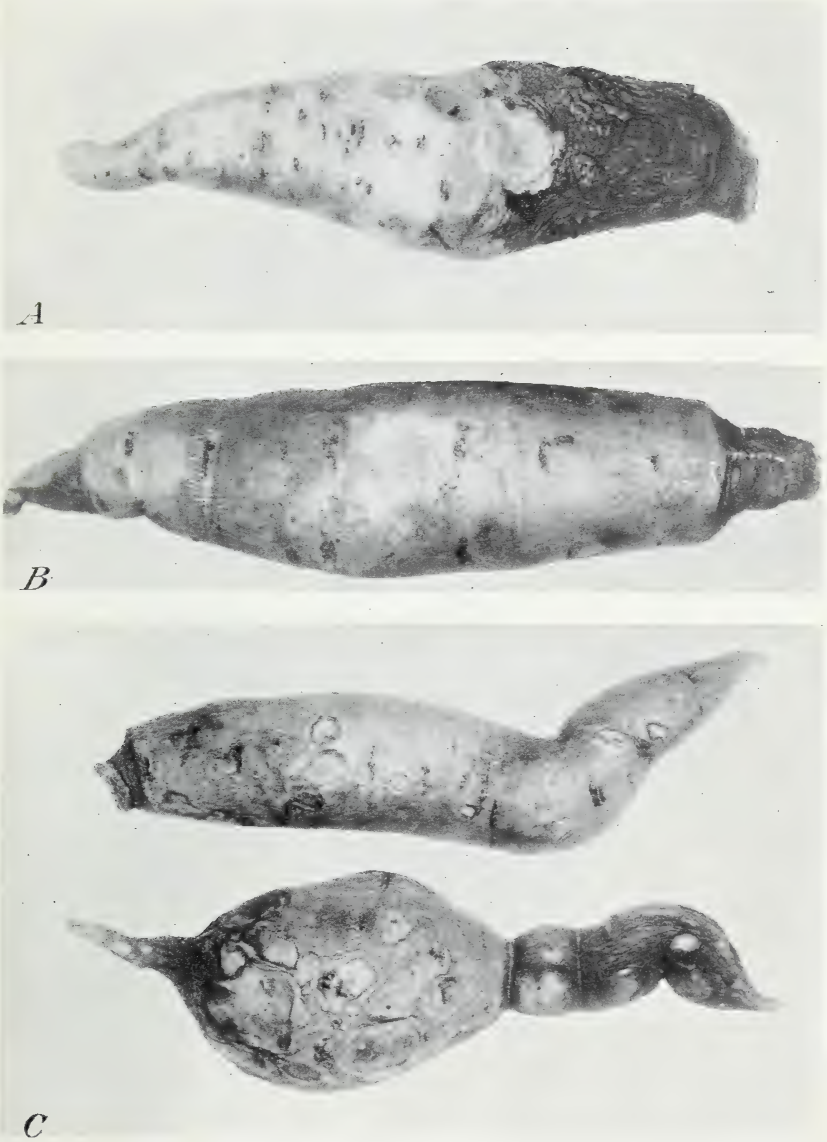
Control may be obtained by careful selection of seed stock to make sure that no diseased, discolored, or badly bruised sweetpotatoes are used. Soil, manure, or compost containing discarded sweetpotatoes or debris from sweetpotato vines should not be used in the hotbed.

Sweetpotatoes showing evident decay should not be stored or shipped to distant markets.

(See *34*, *139*.)

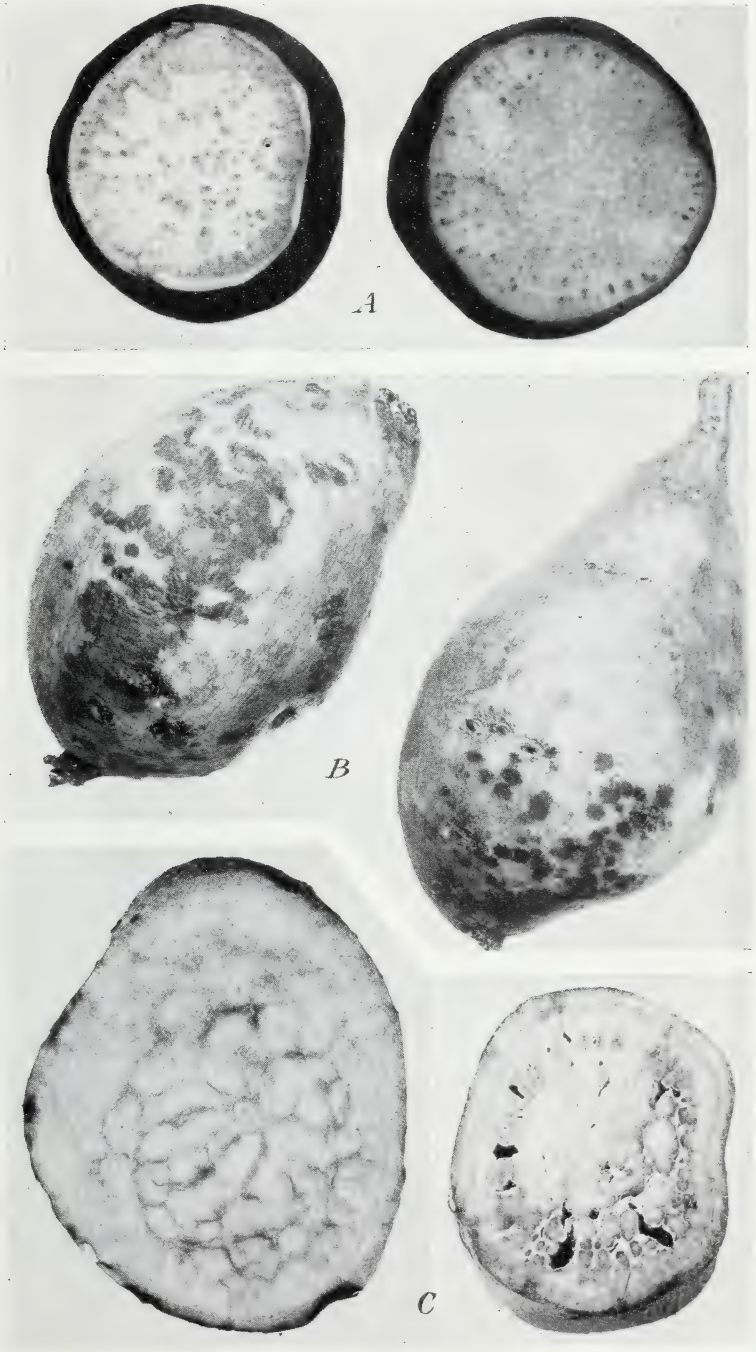
Freezing Injury

Although the sweetpotato is generally believed to be one of the vegetables most susceptible to freezing injury, the average freezing temperature (28.5° F.) is lower than for many vegetables considered more hardy. However, the indirect effects of low temperatures in causing internal discoloration and in favoring the development of decay by certain fungi make it necessary to look with suspicion upon any lot of sweetpotatoes that has been exposed to temperatures below 50° for any great length of time. (See also Chilling Injury, p. 22.) Sweetpotatoes that have been only slightly frozen are characterized by yellowish-brown discoloration in the vascular ring and internal vascular elements and by a yellowish-green water-soaked appearance of the other tissues (pl. 15, *A*). When exposure to freezing temperatures has been so prolonged that ice has formed within the tissues, they collapse immediately upon thawing and the sweetpotato becomes soft and flabby as water is liberated. Roots so affected may dry and

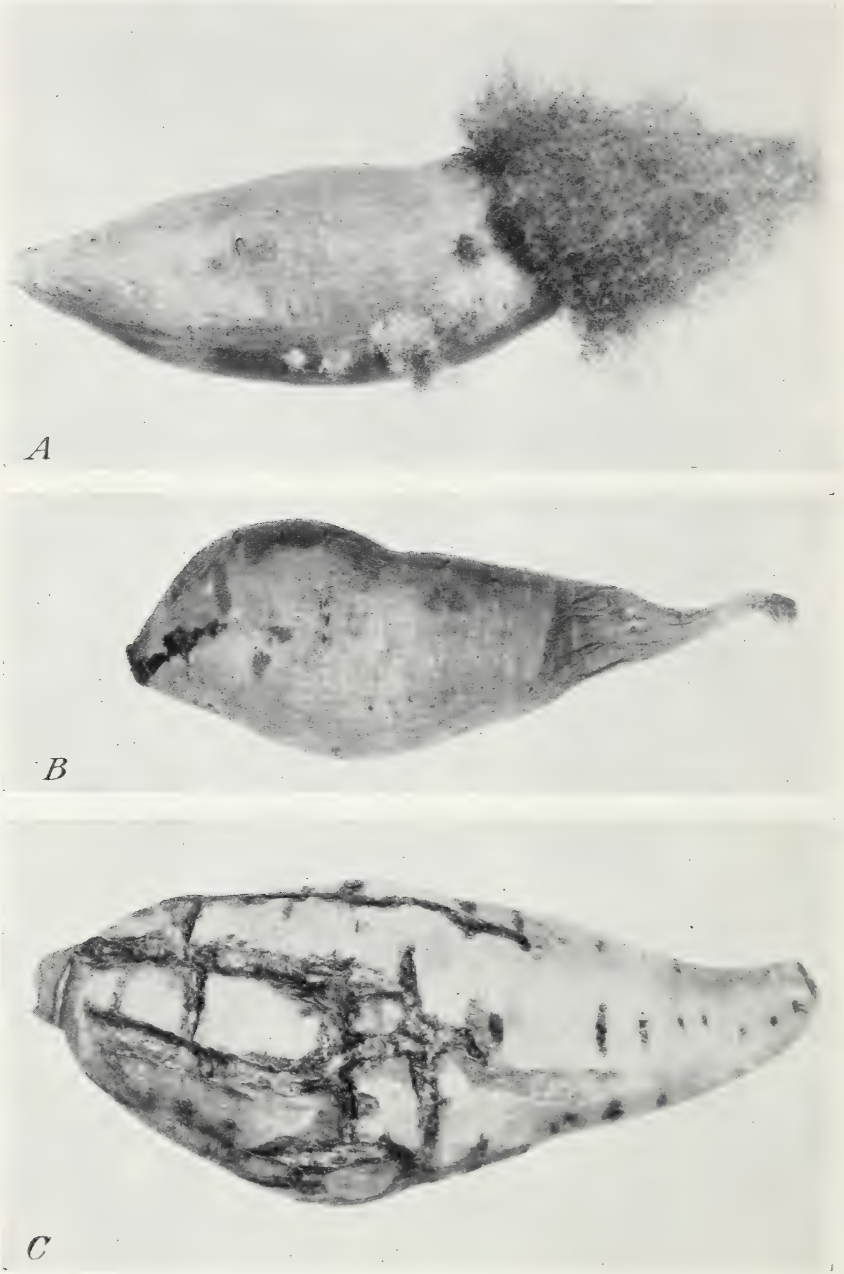


A, Dry rot of sweetpotato; *B*, end rot of sweetpotato; *C*, surface rot of sweetpotato.

A, Foot rot of sweetpotato, showing external and internal discoloration; *B*, soil rot of sweetpotato.



A, Freezing injury of sweetpotato; *B*, scurf of sweetpotato; *C*, internal break-down of sweetpotato.



A and *B*, Rhizopus soft rot of sweetpotato: *A*, Moist stage with "whiskers"; *B*, dry stage without visible mold; *C*, growth cracks of sweetpotato.

become brown, discolored mummies, although usually they become decayed by blue mold.

(See *157*.)

Gray Mold Rot

(*Botrytis* sp.)

Gray mold rot is a minor storage and transit disease, which attacks sweetpotatoes at low temperatures and high humidities. Infection takes place through the ends of the sweetpotatoes or through wounds elsewhere. Decayed tissues are moderately soft and grayish brown and have a starchy odor. The causal fungus can grow well over a wide temperature range, but it usually causes most damage at moderately low temperatures. At the usual storage temperatures this fungus may completely decay infected sweetpotatoes within 2 weeks.

(See also Globe Artichokes, Gray Mold Rot, p. 6.)

Growth Cracks

A severe blemish of sweetpotatoes sometimes occurs in the form of moderately deep lengthwise and crosswise fissures commonly called growth cracks (pl. 16, *C*). Apparently any weather or soil condition that causes irregular or interrupted development of the sweetpotatoes may lead to this cracking. Thus a period of rapid growth due to favorable moisture conditions following drought may result in the development of the trouble. In some regions it has been noted that the application of high-nitrogen fertilizers or stable manure tends to induce growth cracks.

Experimental tests have shown that some varieties of sweetpotatoes are much more likely to produce growth cracks than others. The Southern Queen was found particularly susceptible.

Most growth cracks heal without becoming infected, but occasionally sweetpotatoes have been found on the market with fusarium rot and black rot following the cracks.

(See *46*.)

Internal Break-Down

Sweetpotatoes in storage sometimes develop a break-down of the internal tissues; in advanced cases affected specimens can be detected by their light weight and spongy feeling. When such potatoes are cut it is seen that the internal tissues are pithy or dry and spongy, with cavities forming in the central parts of the roots as the tissues separate (pl. 15, *C*). At times the spongy tissues are white or light yellow and of a cottony texture.

Internal break-down is usually found late in the storage season and is most prevalent in storages that have been kept warm and too dry.

(See *41*, *46*.)

Java Black Rot

(*Diplodia tubericola* (Ell. and Ev.) Taub.)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Since Java black rot apparently does not attack sweetpotatoes until after they are harvested it is of economic importance only from

the storage and market point of view. Although it is a slowly developing rot, it nevertheless causes heavy losses because of its wide distribution, which is probably coextensive with the sweetpotato itself. It can be found in practically every sweetpotato storage house and in storage banks. Losses from Java black rot are, however, usually more severe in the southern part of the United States and in the Tropics than in the northern sweetpotato section.

Experimental evidence indicates that it takes 10 days after infection before symptoms of the decay appear and a month or more before complete decay of the sweetpotato occurs. In storage and on the market the decay in the early stages is brown and moderately firm. As the tissues throughout the sweetpotato (pl. 17, *B*) become involved, the central part is light brown and the skin and tissues just beneath change from dark brown to black as fruiting bodies (pycnidia) form within. Scattered slightly raised pimples indicate the development of pycnidia which are pushing up under and through the skin (pl. 17, *A*). In 3 or 4 weeks these fruiting bodies form in great numbers and are often so crowded as to form domelike elevations of the surface. Eventually the sweetpotato becomes a hard, dry, black mummy (pl. 17, *C*).

CAUSAL FACTORS

The pathogen (*Diplodia tubericola*), like others of its close relatives, occurs in the soil, on sweetpotatoes and other plants, and in plant debris. No infection appears to take place in the field except through wounds at digging time and during handling for storage and marketing. The organism may be carried into storage on roots, and it may be present there in old roots or in debris. Infections through wounds have been obtained throughout a temperature range of 54° to 98° F., with most rapid decay occurring between 84° and 88°. It appears that infection proceeds much faster in moderately dry air than in very humid air because the healing of wounds is retarded; hence decay is more rapid at low humidity (50 to 60 percent). Under conditions of high humidity (90 to 95 percent) the rate of wound healing increases with the temperature between 54° and 89°. Below and above this temperature range the healing of wounds is greatly retarded.

CONTROL MEASURES

Sweetpotatoes promptly cured for 10 days at a relative humidity of 85 to 90 percent and a temperature of 85° F. will develop protective layers in wounds sufficient to prevent infection by the Java black rot fungus and many other fungi that cause serious storage rots.

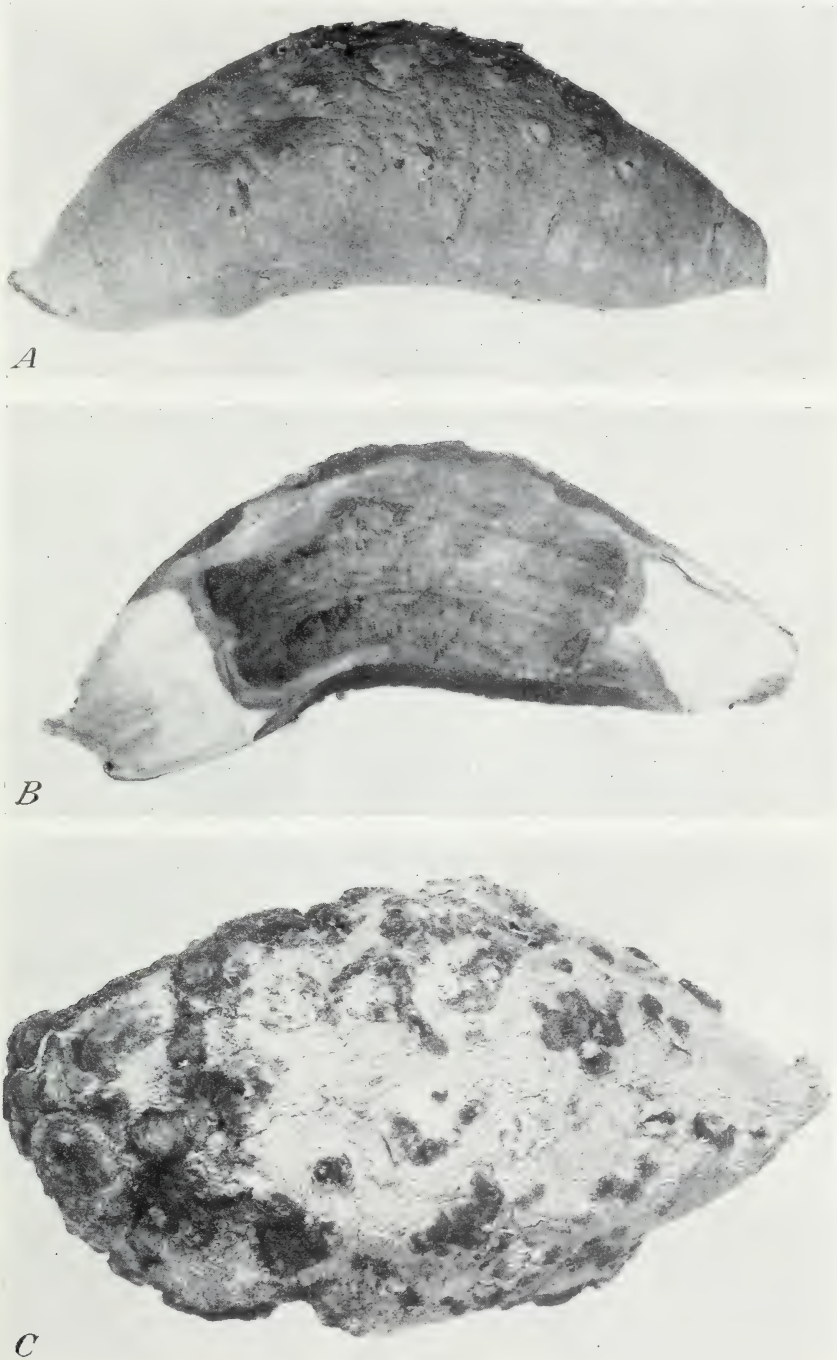
Careful handling of the sweetpotatoes to avoid all unnecessary wounds at harvesting and storage time is one of the most valuable methods for controlling Java black rot.

(See *46*, *134*.)

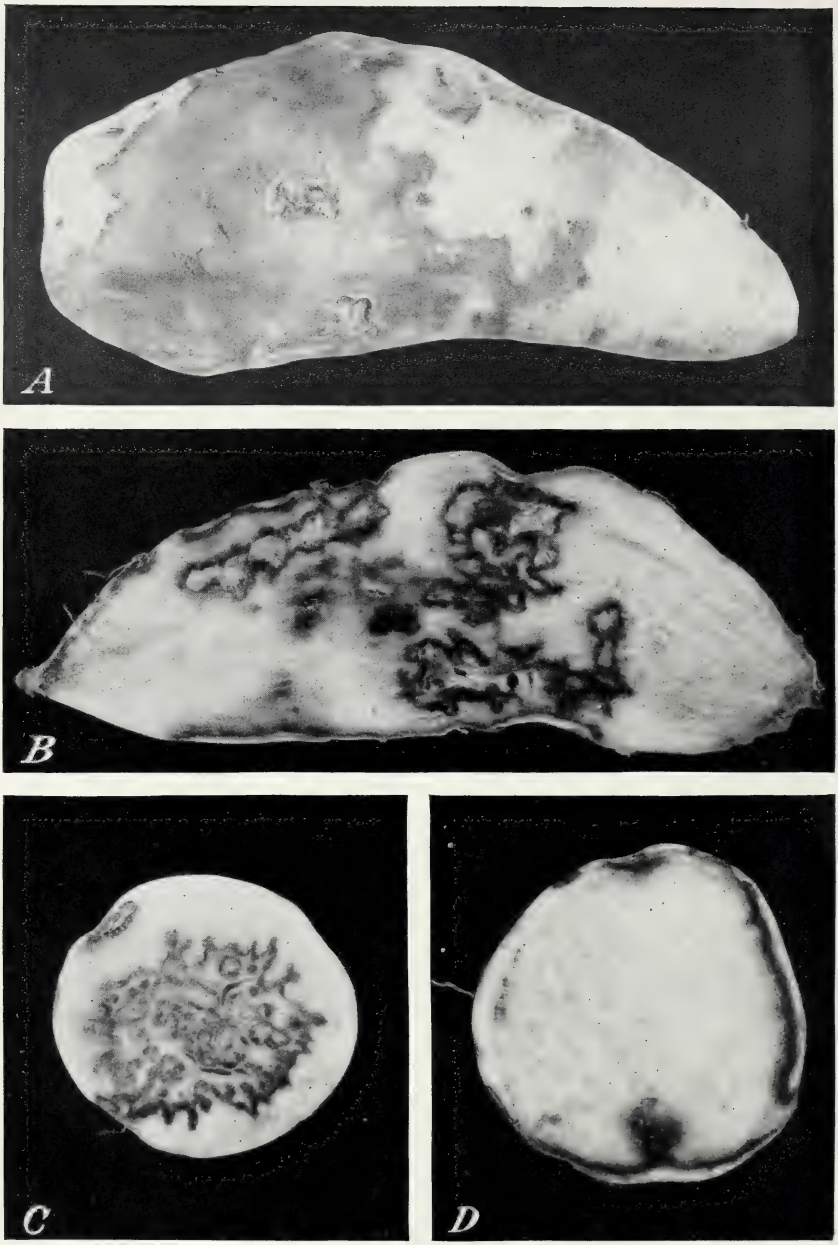
Mottle Necrosis (Ring Rot)

(*Pythium ultimum* Trow and *P. scleroteichum* Drechs.)

Mottle necrosis is of primary importance in the field and sometimes in storage after wet seasons. Sweetpotatoes showing mottle necrosis



Java black rot of sweetpotato: *A* and *B*, Early stage; *C*, advanced mummy stage.



Mottle necrosis of sweetpotato: *A*, Surface view; *B* and *C*, sections showing mottle stage; *D*, section showing band type of discoloration and decay.

are occasionally found on the markets in stock shipped directly after harvesting, but this disease is seldom found in sweetpotatoes shipped from storage. Apparently the infected sweetpotatoes that reach storage develop extensive decay within a few weeks and are discarded before they are marketed (pl. 18, *A*).

The causal organisms are common soil inhabitants that thrive particularly well in wet soils that contain a generous proportion of organic matter. Infection of plants and developing potatoes takes place chiefly through the young rootlets. However, wounded sweetpotatoes are readily attacked. Sweetpotatoes inoculated in wounds and held at moderate temperature in high humidity have been found to develop pronounced decay within 36 to 48 hours and to rot completely in 3 to 7 days.

The early stages of decay following natural infection of sweetpotatoes in the field are characteristically small, sunken, grayish-brown spots and areas about the point of attachment of the secondary roots. Sometimes the causal fungus penetrates deeply within the sweetpotato without much surface discoloration or decay being evident. If the temperature is comparatively low a soft, gray, cheesy type of decay is produced, but under relatively high temperature conditions mottled and marblelike grayish-brown to chocolate-colored areas and pockets are formed throughout the sweetpotato (pl. 18, *B* and *C*). A third type of decay, known as ring rot, is sometimes produced. In this case the grayish-brown surface decay spreads in a band around the circumference of the sweetpotato (pl. 18, *D*). Under the usual curing and storage conditions these bands or rings of diseased tissue soon become dry and sunken. This dry, sunken ring rot stage is somewhat like a type of ring rot caused by *Rhizopus* (p. 28).

The most common causal organism (*Pythium ultimum*) grows well at moderately low temperatures. In experimental work it has been found that the minimum temperature at which infection will take place is near 36° F., the optimum between 54° and 60°, and the maximum about 95°. This temperature relation indicates that under the usual warm temperatures prevailing in the South, mottle necrosis should not ordinarily prove serious.

The use of new soil each year in the hotbed and the practice of crop rotation have been recommended for controlling this disease. Infection at harvesttime may be avoided to some degree if it is found possible to dig the sweetpotatoes during dry weather.

Since the Yellow Jersey, Big-Stem Jersey, and Triumph varieties usually are most severely affected, other varieties should be tried if the soil is known to be heavily infested with *Pythium*.

(See *20*, *37*, *42*, *51*, *113*.)

Mucor Rot

(*Mucor racemosus* Fres.)

Mucor rot is a storage and transit rot that occurs in sweetpotatoes only when they are exposed to high humidity at low temperatures. Consequently it is of minor importance in good storage houses because the temperature is maintained too high for its development.

During transit and marketing, sweetpotatoes sometimes become moist and are exposed to temperatures between 35° and 45° F. Under such conditions this rot may develop.

Most of the infection by *Mucor* occurs through wounds at the ends or sides of the sweetpotatoes and through dead rootlets. The affected tissues are moist and clayish white and have a distinct starchy odor at first. Later they become firm to spongy and, when broken, the diseased tissues pull out in a fibrous, stringy manner.

Mucor rot is often confused with rhizopus soft rot because the causal fungi not only look alike but both also produce soft, watery, stringy types of decay. Although positive differentiation of these two rots is often difficult without making a microscopical study it may be assumed that a decay of this type occurring above 50° F. is rhizopus rot, and one found developing below 50° is probably mucor rot.

The causal organism is present practically everywhere in the air, soil, and water. It produces great numbers of spores in sporangia very similar to those produced by *Rhizopus*. Consequently sweetpotatoes may become contaminated with these spores during harvesting, storage, and marketing. The subsequent development of decay depends upon the availability of fresh wounds, moisture, and low temperatures, which favor infection.

The most important factors in the control of this disease are keeping the sweetpotatoes from becoming moist in storage and in transit and maintaining temperatures above 50° F.

(See *46*.)

Rhizopus Soft Rot

(*Rhizopus nigricans* Ehr. and *R. tritici* Saito)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Rhizopus soft rot is the most important storage, transit, and market disease of sweetpotatoes. It occurs in stock from all sweetpotato regions and is the principal cause of loss of sweetpotatoes during marketing and while they are in the hands of the consumer. Ordinarily this disease causes more loss on the market than all of the other sweetpotato diseases combined.

All varieties of sweetpotatoes are susceptible to rhizopus soft rot, although some may show less decay than others. Handling and storing methods probably have a greater influence on the subsequent development of decay than any natural resistance due to varietal characteristics. Since infections by *Rhizopus* spp. are entirely dependent upon wounds or injuries produced by other diseases, rhizopus rot is not an important field disease but it may affect potatoes in the seedbed.

At moderate temperatures rhizopus soft rot develops more rapidly than any other decay. At favorable temperatures infections may take place in fresh wounds and decay becomes evident in less than 48 hours. Infection occurs most frequently at the ends of the sweetpotatoes but may take place through wounds anywhere. It can completely destroy a sweetpotato within 4 to 6 days. At first the affected tissues are soft and watery, but there is little change in color. Freshly

decayed tissues when broken will, under slight pressure, yield a yellowish-brown liquid and a rather pleasant fermentation or yeasty odor. With age the decaying tissues become cinnamon to light chocolate brown in color but are never black. As water is lost by evaporation the decayed areas become withered and firm, and under very dry conditions the sweetpotato may become a hard, brown mummy.

Although infected sweetpotatoes usually decay completely, under some circumstances only a part will rot and become dry. Side infections through wounds sometimes progress around the sweetpotato, causing the so-called ring rot stage of rhizopus soft rot. Frequently these rings of broken-down tissue shrivel and sink, forming a dry, groovelike ring around the sweetpotato. Dry rot in rings or at the ends of sweetpotatoes may again start active decay under favorable moisture and temperature conditions.

The coarse, white, stringy mold growth, or "whiskers," with glistening white and black spore balls (sporangia), usually serves to identify rhizopus soft rot. This growth of the fungus is conspicuous at the ends and through breaks in the skin of sweetpotatoes held in a humid atmosphere (pl. 16, *A*). However, under dry conditions the fungus may cause extensive decay without any surface mold (mycelium) being visible (pl. 16, *B*).

CAUSAL FACTORS

There are many species of *Rhizopus* that may cause decay of sweetpotatoes, but those that usually cause most serious damage are *R. nigricans* and *R. tritici*. These species are ever present in the soil, water, and air. Consequently, it is safe to assume that all sweetpotatoes are contaminated with one or more of these fungi during harvesting, storage, and marketing. Whether or not infection and decay follow depends upon the moisture and temperature conditions and the presence of fresh wounds on the sweetpotatoes. Surface moisture or fresh moist wounds offer the most favorable conditions for infection by contacting mycelium or germinating spores of *Rhizopus*. For this reason the best protection against rhizopus soft rot are careful handling to avoid wounds and drying and curing the sweetpotatoes as promptly as possible after harvesting.

The various species of *Rhizopus* that cause rot of sweetpotatoes have different reactions to temperature, but they can be divided roughly into two groups. On this basis *R. nigricans* represents the relatively low-temperature group and probably causes most decay. It develops slowly between 38° and 53° F., rapidly between 65° and 75°, and is retarded at temperatures between 86° to 94°. *R. tritici* is the most common species of the high-temperature group. Its minimum temperature for growth is 40° to 48°, optimum 90° to 95°, and maximum near 107°. At temperatures between 65° and 85° either or both of these species of *Rhizopus* may be found causing decay of sweetpotatoes. The rots produced are so similar that it is impossible to distinguish them unless cultural and microscopic studies are made.

CONTROL MEASURES

Since all species of *Rhizopus* commonly invade sweetpotatoes through wounds, it is of greatest importance that harvesting and

handling be done as carefully as possible to avoid wounds. The less handling the better. Prompt curing of sweetpotatoes facilitates the natural healing of wounds and prevents infection. Infections by *Rhizopus* and most other fungi that invade fresh wounds are less likely to occur if sweetpotatoes are cured and stored properly (p. 19).

Since *Rhizopus* spp. produce great quantities of spores on decaying sweetpotatoes in storage, it is advisable to disinfect the storage house and containers before storing a new crop. A spray made of 1 pound of copper sulfate dissolved in 10 gallons of water is recommended for this purpose.

In preparing sweetpotatoes for the market, all unnecessary wounding should be avoided and care should be taken to keep them dry. Sweet potatoes showing any evidence of decay should not be shipped.

(See *45*, *48*, *76*, *77*, *78*, *153*.)

Scurf

(*Monilochaetes infuscans* Ell. and Halst.)

Scurf is one of the most common diseases of sweetpotatoes. It occurs on all varieties and appears to some extent on stock from all shipping regions. Although the causal fungus may cause a brownish discoloration of any or all of the underground parts of the growing plant, the chief damage results from a reduction in market value of the sweetpotatoes on account of their blemished appearance. Otherwise the losses in the field and in storage and marketing are of little consequence.

On marketable sweetpotatoes scurf shows as small grayish-brown spots and blotches that are only skin deep (pl. 15, *B*). These spots may be found anywhere on the sweetpotato, but usually most of them are near the attached end. When numerous infections occur, the discolored spots often run together, making a continuous brown area, and in extreme cases the skin may crack. When such extensive areas of the skin are killed, the sweetpotato loses moisture rapidly and may become worthless. A few discolored spots cause no appreciable damage and are generally overlooked by the trade.

Most of the infections take place in the field, but it is entirely possible that new infections may occur under humid storage conditions. Spots already present may enlarge slightly during storage and transit. Usually shrinkage is slow in storage unless the temperature is high and the air becomes too dry. Severely infected sweetpotatoes in hot, dry storage often crack and wither until they are worthless within 4 to 6 weeks.

The causal fungus grows from infected seed sweetpotatoes to the slips, and on these it is spread to the field. Heavy soils containing an abundance of organic matter favor the development of scurf.

Since the scurf organism is known to live over in the soil and on sweetpotatoes used for seed purposes, the most satisfactory control is obtained by careful selection of disease-free seed stock and by avoiding planting in soil that is known to be infested. Heavy, black, wet soils with much organic matter should be avoided if possible.

(See *36*, *112*.)

Soil Rot (Pox)

(*Actinomyces ipomoea* Person and W. J. Martin)

OCCURRENCE, SYMPTOMS, AND EFFECTS

Soil rot, or pox, is found in all the important sweetpotato-growing regions of the United States. Although the losses vary considerably from season to season, in many localities soil rot is considered one of the most important diseases. It seriously curtails the growth and yield of the plants and blemishes the roots so that their value is greatly reduced.

Sweetpotatoes that show soil rot on the market generally are characterized by dry, brown pits, or pox marks, of irregular size and shape (pl. 14, *B*). The areas infected may vary from less than ¼ inch to 1 inch in diameter. In the early stages the superficial, brown, circular spots are smooth or slightly sunken, but as they enlarge the epidermis over them cracks exposing a cavity with rough lining and irregular margin. These exposed tissues are firm and dry when found on mature roots on the market. Ordinarily they are not followed by soft rot or other secondary decays. Sometimes the root is almost girdled by these blemishes, and frequently the growth of the tissues around the deep pits results in the formation of misshaped potatoes.

CAUSAL FACTORS

Within the past few years *Actinomyces ipomoea* has been named as the causal agent of soil rot. This organism makes very little growth at 68° F. and grows best at 89° and only slightly at 107°. The high temperatures in the Southern States apparently favor the development of soil rot.

The causal organism inhabits the soil and invades the potatoes through the small secondary rootlets. Apparently most of the dissemination of this disease is through transportation of infested soil by seed potatoes, farm implements, animals, drainage water, or wind-blown dust. Experimental evidence indicates that the disease is not transmitted by the use of diseased roots for seed purposes if they have no infested soil on them.

Soil rot is most serious during dry seasons. When sufficient moisture is available the plants are able to keep growing and produce some marketable potatoes even though they are diseased.

CONTROL MEASURES

If disease-free soil is not available for growing sweetpotatoes, it is possible to control soil rot in infested soil by adding sufficient sulfur to make it acid in reaction (pH 5.0).

(See *1*, *22*, *54*, *102*, *110*, *136*, *137*.)

Stem Rot (Wilt)

(*Fusarium bulbigenum batatas* Wr. and *F. oxysporum* Schlecht. f. 2 Wr.)

Stem rot, or wilt, is one of the important field diseases of sweetpotatoes that rarely is found on the market. Like other types of

fusarium wilt the greatest damage is caused by the fungus invading the vascular system of growing plants. Severely infected plants yellow and wilt without producing any marketable potatoes.

Sweetpotatoes produced on slightly diseased vines often develop brownish-black discolorations in the vascular rings, but no external symptoms are evident. Consequently, affected potatoes that get into the markets are detected only upon cutting.

Since sweetpotatoes harvested from frosted vines or those that become chilled later may also show dark discolorations in the vascular tissue, positive diagnosis of this disease on market potatoes is not always possible.

(See *39*, *40*, *44*, *52*, *53*, *80*, *92*, *109*, *111*.)

Surface Rot

(*Fusarium oxysporum* Schlecht. f. 1 Wr.)

Surface rot has been reported from all sweetpotato-growing regions. The amount of loss caused by this disease varies with the varieties grown and with the seasonal conditions at digging time. Sometimes practically every potato is noticeably affected after 6 weeks' storage, and great losses result because of the difficulty in marketing diseased stock.

The early stages of surface rot are characterized by small, circular, light-brown, superficial spots. As decay progresses the spots enlarge and become slightly sunken but change little in color. As observed on the market, most spots range from one-fourth to three-fourths inch in diameter, with their margins sharply marked because of the drying and shrinking of the affected tissues (pl. 13, *C*). Even in the advanced stages the decay seldom penetrates deeper than one-eighth inch. The fact that the spots remain light brown, are definitely circular in outline, and never have any surface mold or fruiting bodies makes the identification of the disease fairly easy.

The causal fungus lives in the soil and invades the sweetpotato through small rootlets at harvesttime and during the early part of the storage period. Infection takes place most readily when potatoes are harvested during wet weather; consequently, surface rot becomes one of the most serious storage diseases after wet seasons. The decay develops so slowly that conspicuous lesions are not usually evident until about 6 weeks after storage. Sweetpotatoes with many lesions shrivel badly in storage and become worthless.

Although there is a chance that new infections may occur in storage if the sweetpotatoes do not cure promptly, it appears doubtful that any new lesions would develop after long storage or during transit. Most surface rot lesions are so dry and firm that little, if any, secondary infection by other organisms occurs during transit and marketing.

Light-skinned varieties of sweetpotatoes are much more susceptible to surface rot than darker skinned ones. The Big-Stem Jersey is more subject to injury than any other variety, but a highly resistant strain of Yellow Jersey has been developed.

Sweetpotatoes should not be harvested during wet weather if it can be avoided. Prompt curing and proper storage conditions (p. 19) will do much to control the development of surface rot.

(See *43*, *72*.)

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